

## **Research and Technology Development to Advance Environmental Monitoring, Food Systems, and Habitat Design for Exploration Beyond Low Earth Orbit**

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Exploration missions will carry crews far beyond the relatively safe environs of cis-lunar space. Such trips will have little or no opportunity for resupply or rapid aborts and will be of a duration that far exceeds our experience to date. The challenges this imposes on the requirements of systems that monitor the life support and provide food and shelter for the crew are the focus of much research within the Human Research Program. Making all of these technologies robust and reliable enough for multi-year missions with little or no ability to run for home calls for a thorough understanding of the risks and impacts of failure. The way we currently monitor for microbial contamination of water, air, and surfaces, by sampling and growing cultures on nutrient media, must be reconsidered for exploration missions which have limited capacity for consumables. Likewise, the shelf life of food must be increased so that the nutrients required to keep the crewmembers healthy do not degrade over the life of the mission. Improved formulations, preservation, packaging, and storage technologies are all being investigated for ways slow this process or replace stowed food with key food items grown fresh *in situ*. Ensuring that the mass and volume of a spacecraft are used to maximum efficiency calls for infusing human factors into the design from its inception to increase efficiency, improve performance, and retain robustness toward operational realities. Integrating the human system with the spacecraft systems is the focus of many lines of investigation.